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**GREEN INNOVATION:
HOW FIRMS LEVERAGE CAPABILITIES, RESOURCES
AND COMPLEMENTARY ASSETS**

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ABSTRACT.

Environmental issues are critical for business either as a constraint or an opportunity. Hence, they should be addressed by firms as a strategic priority integrated in their operations strategy. In order to do so, firms need to develop green capabilities and assets that support their green strategies. This paper discusses the green capabilities necessary to develop green innovation initiatives. It presents a framework that structures the relationship between drivers of green operations strategies, firms' resources and green innovation as a source of competitive advantage. Case study research is used to support and extend the framework. Case study evidences validate the framework, provide additional insights and suggest new lines of research on these topics.

Keywords.

Green innovation; Green capabilities; Complementary assets; Operations Strategy

1. INTRODUCTION

In 1987 the United Nations World Commission on Environment and Development published a report which presented the concept of sustainable development as one that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (UNWCED, 1987). This report gave evidence that business activities were creating pressures on natural resources which altered the carrying capacity of the environment. It was an implicit message for management practices: the current situation would have future implications in business.

In the last decade, executives have paid increasing attention to the sustainability agenda (Bielak *et al.*, 2007; The Economist, 2008). Several companies like Nike (Zadek, 2004) have experienced the interdependence between business and sustainability. In the 1990s Nike’s business was threatened by environmental activists that protested against the unethical working conditions of outsourced factories. First, Nike regarded NGO protests as constraints to business and a reputational issue. Only ten years later did Nike realize that the problem was in their procurement practices, which placed priority on cost and delivery time. In order to solve this, Nike integrated labour criteria in the procurement practices. Indeed, there are diverse perspectives on how sustainability should be addressed in business contexts, which range from treating it as a moral obligation to understanding it as an opportunity.

Sustainability initiatives are spreading all over the world (Appendix 1) with different degrees of implementation performance and extension across business (Appendix 2). This is happening fast, but management practice knows little about how to deal with sustainability issues or how to integrate them into existing practices.

Attempting to provide a contribution, researchers have raised the question of whether environmental management should have its own strategic framework or should be included into operations research frameworks (Angell & Klassen, 1999). This work project intends to address this issue. It aims to contribute to understanding the extent and the context in which firms tackle green issues within their operations strategy, thereby contributing to an emergent topic in operations management research agenda. More specifically, it studies the resources and complementary assets that firms develop to implement green innovation.

This paper starts with literature review on these topics and then presents the buildup of a conceptual framework of green operations strategies. Afterwards, the case study research methodology is presented and the findings are discussed. The conclusion section presents the main insights on how firms leverage resources and complementary assets in the context of green innovation.

2. LITERATURE REVIEW

Many authors have researched and written about sustainability and business. They argue that business and environmental issues are interdependent; hence, sustainability should be regarded as an aspect to be incorporated in the strategy definition process (Elkington, 1994; Hart, 1997; Porter & Kramer, 2006). Porter and Kramer (2006) contributed to clarify the linkage between environmental issues and corporate strategy. They state that each firm's business case for sustainability should be defined by analyzing the linkages between the environmental context and each primary and secondary activity of the value chain. Other authors infer from theory and case study research that environmental strategies – hereby named as green strategies

– must be defined taking into consideration the resource-based view (RBV) of the firm (Hart, 1995; Sharma & Vredenburg, 1998; Lee, 2008).

In the RBV literature, resources are defined as firm-specific assets, capabilities and organizational processes used by the firm to implement its strategy. Resources that are valuable, rare and hard to imitate or to substitute are sources of competitive advantage (Barney, 1991). Capabilities are defined as organizational routines that enable firms to perform distinctive activities (Teece, 1997). There are specific resources, named complementary assets, which enable firms to capture value from the complex bundle of capabilities and assets that support a strategy. For instance, the implementation of process-focused best practices provides a cost advantage when firms have complementary assets such as capabilities for process innovation and implementation (Christmann, 2000).

Researchers argue that green initiatives are drivers of the development of resources and capabilities (Hart, 1995). Therefore, to capture value from those resources and capabilities, green initiatives should be integrated in corporate strategies and linked to the value chain (Porter & Kramer, 2006). However, there is lack of a general framework that contextualizes green initiatives within operations strategy, namely a roadmap that guides management practice through the implementation of green strategies and their coordination with competitive priorities and organizational functions. Azzone *et al.* (1997) reinforce this by stating that generic environmental strategies have been defined by trade-offs between environmental performance and other competitive priorities. Hence, there are no references to the operating conditions that provide the basis for green strategies implementation.

Corbett and Klassen (2006) reinforce this research gap by discussing the implications of the environmental perspective to operations. They argue that green issues “extend the horizons” of operations management practices, a common path in the historical evolution of this field, as illustrated by the evolution from specialized quality control to total quality management and from inventory control optimization to collaboration within the supply chain. The ongoing discussions around the conditions and circumstances under which green initiatives are integrated in existing operations strategies are establishing a research field on green operations strategies.

Green operations strategies are defined as environment-focused strategies that firms develop within their operations, which are driven by internal and external forces and supported by resources, capabilities and complementary assets. They require that the firm sets its environmental performance as an operations objective (Jiménez & Lorente, 2001). However, researchers discuss whether defining environmental performance as an operations goal strengthens existing operations objectives or whether there is a trade-off between environmental performance and operational performance (Jiménez & Lorente, 2001). Gupta (1995) has found that environment-focused continuous improvement initiatives contribute to the achievement of operations objectives. By monitoring the environmental performance of its processes, the firm is also monitoring and assessing its overall operational efficiency. Thus, if green operations strategies are precursors of continuous improvement initiatives, they may leverage general operational results, which may provide an opportunity for the firm to stay ahead of the industry (Gupta, 1995). This is a significant issue for the research presented in this paper. To consider environmental performance as an

operations goal may be a determinant of the implementation of green operations strategies. To know how to integrate green initiatives in operations, in order to achieve better operational results, can be a source of competitive advantage.

To understand green operations strategies, we need to understand their driving forces. Internal forces are voluntary drivers, such as Board's commitment or investors, whereas external drivers comprise regulation, clients' demands or industry standards (Gupta, 1995). They influence the level and the extent of responsiveness of green operations strategies. As shown in Appendix 3, some authors have tried to establish a classification of green operations strategies based on responsiveness criteria. They all agree that the drivers influence the level of responsiveness, which means that a reactive strategy is driven mostly by external factors and a proactive strategy is driven mostly by internal forces. Hence, in the adoption of green strategies, firms react to or predict changing internal and external environments, which requires the development of new capabilities or the reconfiguration of existing ones. It is argued that these capabilities are competitively valuable when they derive from a proactive strategy. In Sharma and Vredenburg's research (1998), such capabilities explain the variance in competitive elements (e.g. cost reductions, process and product innovation) among a group of firms with reactive and proactive strategies. So, it is suggested that a proactive green strategy drives the development of capabilities that result in superior performance (Sharma & Vredenburg, 1998).

Green capabilities are distinctive competences of firms to develop green initiatives, or to integrate them into existing initiatives, with a focus on environmental performance. They interact with operations capabilities in a complex system (Jiménez

& Lorente, 2001). Such green capabilities are related to value chain activities because they support green initiatives that tackle the environmental impacts on the value chain (Porter & Kramer, 2006). Researchers have identified green capabilities for continuous innovation (Sharma & Vredenburg, 1998), supply chain collaboration (Lee & Klassen, 2008) and supply chain integration (Vachon & Klassen, 2006).

The next section presents the framework for this study, which establishes a relationship between green operations strategy and competitive advantage supported by firms' green capabilities.

3. FRAMEWORK

Our framework conceptualizes the relationship between firm-specific capabilities and assets and green innovation processes in the context of green operations strategies (Figure 1). The model presented aims to contribute to the definition of a general framework for green operations strategies.

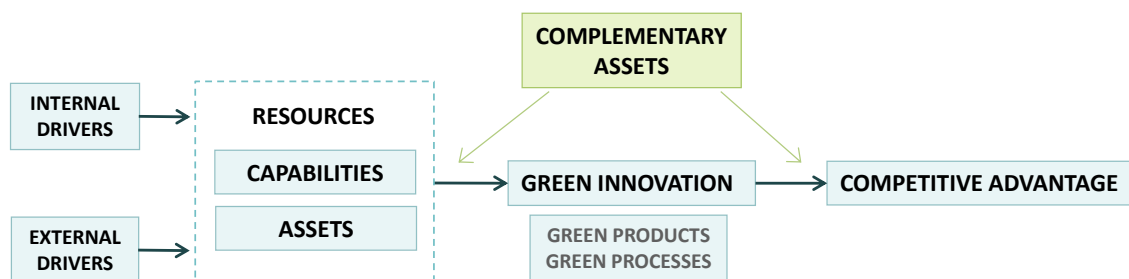


Figure 1. Framework

Internal and external forces are the drivers of the development of capabilities and assets in firms (Gupta, 1995). Such resources support the definition and execution of a green operations strategy (Barney, 1991), specifically green product and process innovation. Complementary assets enable green innovation (Christmann, 2000), but also have an effect on competitive advantage (Porter & Kramer, 2006); they mediate

the relationship between the firm's set of resources and the firm's superior performance.

Internal and external forces converge to influence the development of resources because they create pressures on firms to tackle critical green issues. Such issues are critical to the firm either because they create a business opportunity or because they act as a constraint for business.

Hence, the firm will develop resources to create the organizational and operational conditions to implement green process and product innovation initiatives, as reaction to the drivers of green innovation (Appendix 4). Those resources (physical, human or financial) and capabilities enable the firm to implement green innovation initiatives with the support of complementary assets. We can understand the mediation of complementary assets in the relationship between resources and green innovation by looking at the role of a brand. General Electric (GE) has capabilities of product innovation and technology integration that allows it to deliver to market a wide variety of products and services in distinct areas such as aviation, healthcare and oil&gas. GE has numerous innovations in emergent fields like clean energy. To amplify the value of green innovations GE has created a brand – Ecomagination¹ – which is a complementary asset because it amplifies the visibility of these innovations in the market. GE is replicating this effect with Healthymagination for healthcare innovations.

Green innovation comprises both green product and process innovation. A green product is defined as a product or a technology that was developed to generate lower environmental impacts than the ones in the market. Green process is an

¹ GE's Ecomagination in <http://ge.ecomagination.com/>

operations process, such as procurement, manufacturing, logistics and distribution, which was developed to have a lower environmental impact. In general, a product or process with lower environmental impact has a more efficient use of natural resources or other materials, generates lower pollutant emissions, generates lower amounts of waste and has safer waste disposal options.

The study follows the RBV perspective by assuming that, in the green innovation context, firm assets are not creators of competitive advantage by themselves. It is the fit with green capabilities that enables product innovation and process innovation and that may result in superior performance. Nevertheless, this fit is not sufficient. The firm must be able to capture value from green innovation with complementary assets. This is the key to make it worthy for the firm to implement green operations strategies based on green product and process innovation. Otherwise, embedding environmental issues into operations strategy can prove to be a source of costs, rather than superior performance. It is the complex internal network of firm-specific resources (assets and green capabilities) and complementary assets that can be a source of competitive advantage.

Two matrices were developed from the framework: one that maps green innovation initiatives in firms and another that crosses them with their relationship with driving forces. The first matrix is presented in Figure 2. Firms develop green process and product innovation initiatives in different degrees, in the continuum between low and high levels of innovation in product and in process.

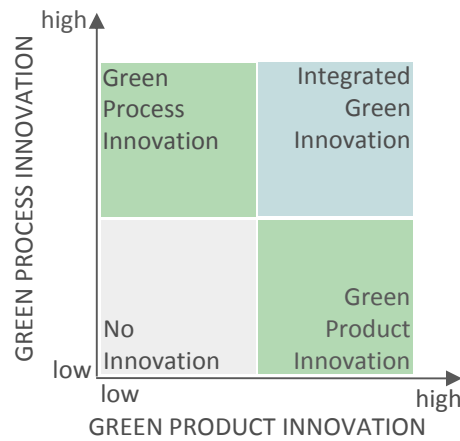


Figure 2. Green Innovation Matrix

Green product innovation and green process innovation can exist as rather isolated initiatives, i.e. a firm does product innovation or process innovation initiatives, or in an integrated way. Integrated green innovation takes place when a firm intentionally develops a green product that requires the development of a green process or vice versa. The second matrix, named Green Innovation–Green Strategy Matrix is presented in Figure 3. It takes the categorization of green innovation and crosses it with the outcome of internal and external drivers in green strategy. In this matrix, regardless of the level of responsiveness to driving forces, firms can exhibit the three expected types of innovation.

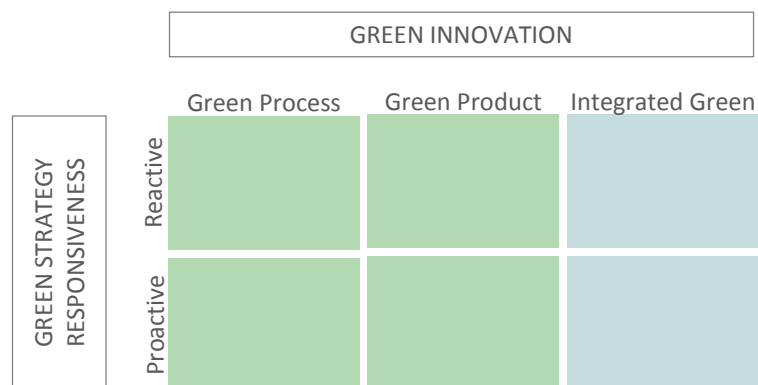


Figure 3. Green Innovation–Green Strategy Matrix

Both matrices are starting points for case study analysis. They support the classification of the case studies according to type of green innovation initiatives and

level of responsiveness of green operations strategy, useful to understand case study findings. The following section presents the case study research methodology.

4. CASE STUDY METHODOLOGY

The case study methodology was chosen as the empirical research method. Case studies are useful tools when the events studied cannot be controlled by the researcher, when processes are being understood and when question about causality (why) and functionality (how) are posed. They are a preferred research method when the research focus is an existing contemporary phenomenon happening in real business contexts (Yin, 2003).

This section begins with an overview of the methodology and then moves on to the description of data collection and measures and preliminary data analysis. The case study research began with the definition of a method to select the firms that would be studied. Firstly I defined the following case study firm profile: operations in Portugal, product and/or process innovation initiatives and presence of environmental elements in their operations. To build a list of potential case studies that fit this profile I looked for firms that were members of the Portuguese regional network of the Business Council for Sustainable Development (BCSD Portugal) or members of COTEC Portugal, a business organization for innovation. Secondly, I designed a semi-structured interview protocol that allowed me to collect information about each firm's capabilities and about the responsiveness and the outcomes of the firms' green operations strategies.

Using the list of potential case studies as starting point, I screened public sources of information for about 30 firms and shortlisted 15 to be contacted for

interviews. The sources of information used are shown in Appendix 5. In the first round of contacts, shortlisted firms were contacted by e-mail and six agreed to participate in this work project as case studies. A second round of contacts targeted firms who could provide additional information. This added two firms to the previous group.

This case study research studies the green capabilities of five firms in the manufacturing (Ind SA, Paper SA and Pulp SA), property management (Property SA) and electromechanical (Energy SA) sectors and three professional services firms as external sources of capabilities in the construction, environmental management and business intelligence consulting sectors (Bio SA, Eco SA and IT SA). Firms' identity, information from interviews and non-public documents are kept confidential.

4.1 Data collection and measures

This section describes the data collection method and the measures used to analyze data. The information collected includes primary and secondary data; the measures cover green capabilities, responsiveness of green operations strategy and outcomes of green innovation.

In order to list the relevant capabilities in the context of green innovation, I did a preliminary literature review. It helped to define a rather comprehensive list of green capabilities for the case study research. The green capabilities were divided in seven groups and each group was refined to contain those most relevant to the research. The final list of green capabilities used in case study research and the references of the preliminary literature review are shown in Appendix 6.

The responsiveness of green operations strategies had to be measured in order to understand whether a firm was reactive or proactive; hence, I defined a set of

criteria as a proxy of firms' responsiveness. The criteria comprised identification of the drivers of the green strategy (either voluntary or external pressures), intensity of environmental regulation, connection of environmental initiatives to corporate objectives (Jimenez & Lorente, 2001), frequency and extension of environmental initiatives (Azzone *et al.*, 1997) and decision structure. All variables were scored to measure the level of responsiveness of case study's green operations strategy. The set of criteria and the scores for each variable are shown in Appendix 7.

A third aspect covered in the interviews was the collection of performance indicators like expenditure and return on innovation and green initiatives, which were required to measure the outcomes of green innovation and are shown in Appendix 8.

Case studies framework and methodology are usually built around multiple sources of information (Eisenhardt, 1989; Yin, 2003). This case study research uses primary and secondary sources of information.

The primary sources of firm-specific information were eight semi-structured interviews – six in person and two by e-mail. In-person interviews had an average duration of 85 minutes each. Interviewees were firms' managers, heads of department or internal advisors, responsible for sustainability and innovation departments. Five in-person interviews took place at the firms – two in Lisbon, one in the Center and two in the North – and one of them was conducted by telephone as the interviewee was an expatriate working in an office in Spain. They were asked to identify and describe their firm's green capabilities based on the given list (Appendix 6), to identify the level of responsiveness based on a set of criteria (Appendix 7) and to provide information of firm's performance (Appendix 8). Along the interview, interviewees were probed to

describe in further detail some aspects that seemed relevant, as well as to clarify whether the referred capabilities were internal or external. The three professional services firms were asked to provide information about their business, particularly the external sourcing of green capabilities. After a previous analysis of interview results, there was the need to complement some of them with three follow-up e-mails.

The secondary sources of information consist of confidential documents provided by the firms, firms' website contents, sustainability reports and accounts reports (for firm-specific information) and sector-specific reports. This information was helpful to complement primary sources and to understand each industry's business context and environmental pressures.

4.2 Preliminary Data Analysis

The Green Innovation-Green Strategy Matrix derived from the framework functions as a classifier of firms according to their responsiveness and green initiatives, so it is a support to case study analysis. To position firms, I identified green innovation initiatives from preliminary screening of interviews' data and sustainability reports and mapped them in the Green Innovation Matrix. Next, using interviews' information I measured firms' responsiveness and contrasted it with the first matrix to find their positioning in the Green Innovation-Green Strategy Matrix. These steps are shown in the following Figures 4, 5 and 6.

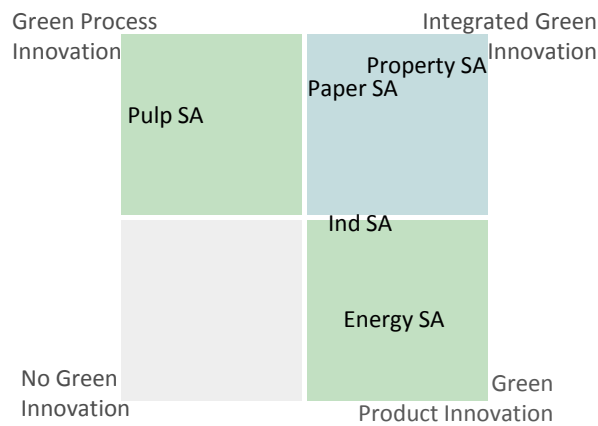


Figure 4. Position of firms in the Green Innovation Matrix

In the upper left area is Pulp SA that has only green process initiatives because its product is a commodity. In the bottom right area are Ind SA and Energy SA that have mostly green product innovation, despite Ind SA being quite close to the frontier to the integrated green area. The firms positioned in the integrated green innovation area (Paper SA and Property SA) evidenced integration between product and process. At Paper SA, process innovation has effects on product innovation (and vice versa); at Property SA product innovation has repercussions on process innovation.

To classify responsiveness, I defined a scoring structure for each set of criteria described in “Data Collection and Measures” and listed in Appendix 7. Interviewees’ responses were attributed a score and the sum of scores for each criterion resulted in the firms’ total score. For criteria with multiple non-exclusive hypotheses, an average score was calculated. The results are presented in Figure 5 and Appendix 9.



Figure 5. Level of responsiveness of firms’ green operations strategies

The combination of the positioning in the first matrix and the scores enabled to map firms in the Green Innovation–Green Strategy Matrix. Figure 6 shows the positioning of firms according to its responsiveness and its green innovation initiatives.

		GREEN INNOVATION		
		Green Process	Green Product	Integrated Green
GREEN STRATEGY RESPONSIVENESS	Reactive		Ind SA	Paper SA
	Proactive	Pulp SA	Energy SA	Property SA

Figure 6. Mapping of firms in the Green Innovation-Green Strategy Matrix

As shown in Figure 6, firms with green innovation initiatives, as extensive as integrated green innovation, can have a reactive strategy.

The description of resources obtained from the interviews was grouped by sets of capabilities and is synthesized in Appendices 10-14. A preliminary analysis of each firm extracted the most relevant aspects and fit them in the framework (Appendices 15-19). Further case study analysis was performed by crossing findings from primary and secondary sources, including information about external sources of capabilities.

After preliminary analysis of case studies, I found that data measures could be improved with additional measures to characterize responsiveness. The research methodology would have benefited if the characterization of proactive initiatives of reactive firms, when they go beyond regulation compliance, had been considered. Nonetheless, even without this measure, some conclusions could still be drawn. The data collection also created limitations because economic indicators for the return on innovation expenditure were not provided by firms. So, to be able to identify sources

of competitive advantage I collected data from sustainability and accounts reports. The interviewees were people with a wide experience on green innovation initiatives of the firms and they were able to identify and describe green capabilities in all groups. Nevertheless, it would have been useful to interview more people from the firms to provide detailed information about specific capabilities. When this was necessary during the case study analysis, I used follow-up e-mails to ask for detailed information.

5. CASE STUDY FINDINGS

This section begins with a description of relevant drivers of green operations strategies and an analysis of key firms' resources. Then, I present significant links among the groups of capabilities and between the drivers and the resources. Next, I describe the capabilities that can be acquired from external sources, as well as the firms' complementary assets. Finally, I substantiate the integration of drivers, resources and complementary assets and evidence the links between them.

5.1 Drivers of Green Operations Strategies

The group of variables used to identify the drivers of green operations strategies (as shown in Appendix 7) functioned as a proxy to the responsiveness and commitment of the firm to the environment. All firms, regardless of being reactive or proactive, defined their environmental initiatives as consistent, scheduled and frequent patterns that were strategic and extended corporate-wide (connected with corporate goals). In terms of drivers, the case studies are divided in two groups: one that is highly driven by intensity of environmental regulation and another with lower pressures from regulation in which the internal driver is the most significant. The firms that are highly

regulated are the ones in which regulation, clients' demands and industry standards are the most significant drivers.

On the one hand, for firms intensely pressured by regulation green issues are a constraint that must be addressed because it may harm business. Potential threats include costs with non-compliance and loss of license to operate. Aware of these threats, firms consider green initiatives as strategic because the pressure of regulation is constant. Environmental regulation is a dynamic process in which emission limits are periodically reviewed for more restrictive levels to be adopted. In addition to this, increases in production output make emission levels rise; firms have to be able to accommodate this variability without being penalized. Hence, intense regulation drives firms to implement green operations strategies to stay ahead of regulation. By doing this, they are adopting a proactive behaviour in which they react strategically to future changes in regulation. This happens in Ind SA, Paper SA and Pulp SA.

On the other hand, firms to which the impact of regulation is softer, also behave strategically in what concerns green initiatives because an internal factor drives that behaviour (e.g. Board). This is the case of firms that approach green issues as a business opportunity. When their driver is solely internal, they are creating a potential to reap first movers' advantages in the future. By voluntarily integrating green issues into their operations strategies, they increase their reputation in the market and in the industry and also set the ground to influence future regulation. At Property SA, a proactive firm, environmental performance goals are part of corporate and operations strategies. When they began implementing this strategy, there were no signs of future regulation that would create constraints. In fact, they had almost no

pressure from environmental regulation. This strategy has paid off: their green operations strategy adds value to property and first-mover advantages enable them to influence regulation and best practices of energy efficiency in buildings.

5.2 Internal Green Capabilities

The most relevant internal capabilities found in case studies are presented in Table 1 grouped by sets of capabilities and associated with a constraint or an opportunity.

Table 1. Relevant internal green capabilities from case study findings

DEVELOPMENT OF GREEN CAPABILITIES	ENVIRONMENT AS...	
	CONSTRAINT	OPPORTUNITY
GREEN PROCESS INNOVATION		
- Reduce emissions per unit of product in production process	•	
- Improve materials' use efficiency per unit of product in production process		•
- Improve energy efficiency per unit of product in production process	•	•
- Search for alternative sources of energy	•	•
GREEN PRODUCT INNOVATION		
- Design for lower energy consumption during use		•
- Design to replace virgin materials		•
- Design for dematerialization		•
- Design for lower environmental impacts in production	•	•
- Generation of green low-cost solutions		•
- Design for recyclability	•	•
MONITORING		
- Anticipation of future regulations	•	
- Anticipation of future industry best practices	•	
- Identification and assessment of operations' environmental impact	•	•
- Memory of product/process changes and performance progress		•
- Internal diffusion and share of relevant information on green issues		•
JOINT PROBLEMSOLVING		
- Internal collaborative processes for problem solving		•
- Multifunctional internal teams		•
- Inter-firms working groups	•	•
SUPPLY CHAIN BONDING		
- Supply chain coordination in reverse logistics		•
- Environmental criteria in suppliers' selection and procurement criteria	•	•
STAKEHOLDER RELATIONSHIPS		
- Disclosure and reporting of environmental corporate information	•	•
- Joint participation to approach green issues (conferences, consortia)	•	•
- Lobby to address industry's relevant environmental issues	•	•
HUMAN RESOURCE ENGAGEMENT		
- Training programs for general and operational environmental issues	•	•
- Incentive systems to reward pro-environmental behaviours at work		•
- Operational budget flexibility to experiment on green initiatives		•

Green process innovation requires the capability of making continuous changes to the production process, either incremental or radical, in order to improve

environmental performance. Energy efficiency and CO₂ emissions were the most significant concerns for firms with energy-intensive manufacturing, which had capabilities to develop processes that conserve energy and to develop cheaper alternative energy sources. Paper SA, Pulp SA and Ind SA had the capability to use process scraps and waste to produce energy for the manufacturing process because of their disposal of energetic organic materials that could be burned to produce heat. Materials' efficiency was also significant, especially to firms with the ability to control it. They developed capabilities to manufacture the same product using fewer raw materials and to increase materials' intrinsic productivity (in the case of natural resources). Emissions are a critical aspect of compliance, especially to firms in the Emissions Trading System. These have developed the capability to reduce incrementally its CO₂ emissions level in order to trade carbon credits (from CO₂ tons they did not emit) in the carbon market.

The green product innovation initiatives are enabled by the development of capabilities to design a product with lower environmental impacts along the value chain (Appendix 23). The most relevant were capabilities to substitute virgin materials, to use fewer materials, to improve energy efficiency during use, to lower impacts in production and to design for recyclability. All of these have cost reduction effects. Property SA has a capability to design for recyclability, i.e. to develop a building for future dismantlement or refurbishment. Building components are recovered and included back in the refurbishment process or sent to recycling units or appropriate end-of-life sites. Paper SA develops products with fewer raw materials and with recycled materials.

Monitoring capabilities were an important group of capabilities and some of them stood out as the most significant. Anticipation of regulatory, market and industry trends is crucial for firms to stay ahead of competitors or to timely deal with future pressures. Studied firms do not go through the full monitoring process, but they have the capability to integrate external monitoring in their operations. External monitoring sources are industry associations. Paper SA, Pulp SA, Ind SA and Property SA are members of national industry associations, which are represented at European level and screen regulatory trends and disclose them to members. Other relevant monitoring capabilities are to identify, measure and assess operations' environmental impact and to produce memories of product/process adaptations according to environmental and economic performance. They enable firms to control environmental performance and progress in parallel with operations strategy objectives. Monitoring outputs are valuable inputs to strategic decision making.

The identified joint problem solving capabilities are capabilities to integrate internal and external sources of knowledge and apply it to the development of green innovation. The capability to develop internal collaborative processes was the most frequently found. Most of the firms had multifunctional teams to discuss green initiatives, review performance and define improvement measures. Property SA has a committee with diverse working groups (environment, health and safety, business chain, risk management). Paper SA has internal and external advisory groups connected to the Board and marketing works with production teams in new product development. Other frequent initiatives take place with suppliers, like innovative

consumer products development at Ind SA, or with R&D centers, like the research to increase natural resources productivity at Paper SA.

The identified supply chain bonding capabilities developed in procurement or production of raw materials and suppliers' selection. The capability to coordinate the supply chain in reverse logistics operations allows Ind SA to optimize recycled materials recovery. For industrial sites outside Iberia these materials are acquired from recycling firms, whereas in Iberia they had to vertically integrate the sourcing of recycled materials. Pulp SA developed capabilities to select suppliers with environmental credentials. The firm has a certified environmental management system (EMS) that requires that suppliers meet performance standards. Pulp SA defined environmental criteria for suppliers and service providers and complemented it with training programs as an incentive to standards' compliance. Paper SA have developed capabilities to create bonds with suppliers of raw materials, through training programs and rewards for efficiency and good practices, in order to increase productivity and ensure quality standards for raw materials.

The capabilities discussed previously are the most relevant for green innovation. Two other types of capabilities – human resources engagement and stakeholder relationships – were not as significant. Regarding human resources engagement, all firms had the capability to develop training programs for their employees. At a larger extent, only Property SA demonstrated to have bonus schemes based on pro-environmental behaviours and budget flexibility for managers to test new green innovation initiatives. In what concerns relationships with stakeholders, firms' practices were similar in content but contrasting in extent. All firms studied

report their environmental performance regularly, but with different degrees and frequency. Paper SA, Pulp SA and Ind SA publish sustainability reports yearly or every two years, Property SA releases yearly reports and Energy SA has disclosed one report so far. Property SA sustainability reports are checked by accredited firms. The firm also discloses third-party reports about their environmental performance and progress, all available in the firms' website. Energy SA sustainability report of 2007 is only public source of information on its environmental performance and it is not available on the firms' website. It identifies environmental initiatives and presents some metrics, but no performance progress. By disclosing environmental information firms create an internal pressure to establish and achieve environmental goals; they are assuming their environmental impacts, as well as action plans to deal with them.

Firms engaged in working groups of industry associations have developed capabilities to lobby for relevant environmental issues and to organize events to discuss green initiatives and disclose their practices. These capabilities are more developed in firms that are first movers in terms of green initiatives, such as Property SA, and firms with intense regulatory pressures, such as Ind SA and Paper SA.

5.3 Links between Drivers and Green Capabilities

In addition to the most relevant capabilities, which enabled green innovation initiatives, I found interesting linkages between these capabilities and the drivers. The cross-comparison between level of responsiveness (reactive vs proactive) and capabilities developed by firms shows that a firm with a reactive strategy may develop in time an extensive set of green capabilities across all groups that go beyond the capabilities needed to react to external pressures.

Regardless of the degree of proactivity, case studies evidence linkages between specific drivers and green capabilities. To understand these linkages, I studied in depth each driver's connection to the firms' green capabilities, green initiatives and the respective goals. They are synthesized in Table 2.

Table 2. Links between drivers and capabilities found in case studies.

DRIVERS		GREEN CAPABILITIES	MAIN GOALS	Energy SA	Ind SA	Paper SA	Pulp SA	Property SA
INTERNAL	Board	Green process innovation	Efficiency; Increase operational margins		•			•
		Monitoring	Assess green initiatives performance					•
		Relationship w/ stakeholders	Support other capabilities		•			•
	Operational efficiency	Green process innovation	Efficiency; Increase operational margins		•	•		•
		Green product innovation	Intensify green process results			•		•
		Joint problem solving	Intensify green process results			•		•
		Supply chain bonding	Intensify green process results		•	•		•
EXTERNAL	Clients	Green product innovation	Market needs and demands	•	•	•		
	Public, NGO	Relationship w/ stakeholders	Reduce pressures; improve reputation			•		
	Licensing; Regulation	Green process innovation	Compliance; Efficiency (secondary goal)		•	•	•	
		Green product innovation	Compliance	•	•	•	•	
		Monitoring	Assess compliance efforts	•	•	•	•	

Ind SA and Paper SA's drivers of green operations strategies are external pressures, so they expect green initiatives' outcomes to directly deal with those pressures. Yet, these firms have verified that green initiatives have secondary outcomes such as operational efficiency. This is why they are proactive in developing capabilities to implement green initiatives that go beyond compliance actions, as seen in Table 2.

5.4 Links between Green Capabilities

Besides links between the drivers and green capabilities, I have also come across with links among green capabilities. A synthesis of these linkages is provided in Table 3 below, which is also presented in Appendix 24 with references to case studies.

Table 3. Links between green capabilities found in case studies

	Green Process Innovation	Green Product Innovation	Monitoring	Joint Problem Solving	Supply Chain Bonding	Relationship w/ stakeholders	H.R. Engagement
Green process innovation	•	•	•	•	•		•
Green product innovation	•		•	•			
Monitoring	•	•		•	•	•	
Joint problem solving	•	•	•			•	
Supply chain bonding	•		•				
Relationship w/ stakeholders			•	•			
Human resources engagement		•					

Green process and product innovation are the capabilities with more linkages to other capabilities. The other capabilities work as supporting capabilities to these and also evidence linkages among them in the relationship that is identified in Figure 7.

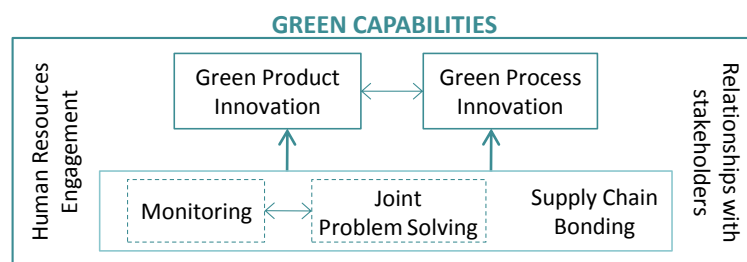


Figure 7. Relationships among the group of capabilities from case studies

At Property SA, outputs from monitoring capabilities support internal joint problem solving processes from which result improvement measures to the product. At Paper SA, outputs from monitoring capabilities support joint problem solving (integration of external expertise) from which result improvements in processes; this network includes supply chain bonding that reinforces green process innovation. At Ind SA joint problem solving capabilities (alliances with suppliers) and long-term relationships with stakeholders support green product innovation capabilities. This firm has supply chain bonding capabilities that reinforce green process innovation capabilities. At Pulp SA monitoring capabilities (integrated management systems) and internal joint problem

solving (multifunctional teams) support green process innovation. At Energy SA internal joint problem solving capabilities support green product innovation.

5.5 External Green Capabilities

When firms plan a green initiative, they may find they do not own the resources to execute it. They need to develop them internally or to acquire them. Interviews with services firms gave evidence of some green capabilities available in the Portuguese market (Appendices 20-22). A subsequent Internet-based research showed that all green capabilities in this case study research are offered in international markets.

Ind SA did not have a capability to identify their critical environmental issues, so they contracted an international consulting firm. Then, to use the insights provided from the outside, Ind SA has been developing the capabilities to integrate the referred issues into their vision and mission and their operations strategy. Property SA went to the market to acquire external monitoring capabilities to follow environmental performance and progress that is integrated with their internal monitoring and decision making processes. Paper SA has internal green process innovation capabilities but it also acquires process innovation capabilities from the market, in which there are robust state-of-the-art technological solutions. The external capabilities acquired are integrated in its own green process innovation capabilities with the support of internal joint problem solving capabilities.

Case study findings show that external capabilities and assets work together with internal capabilities for successful green strategy execution. I have found that firms that acquire capabilities and assets in the market have capabilities to integrate internal and external capabilities.

5.6. Complementary assets

Complementary assets enable firms to develop green innovation initiatives and to capture value from them. The ones identified in the case studies were brands, multifunctional teams (e.g. operations and marketing functions) and IT systems.

Paper SA has multifunctional working groups (engineering, marketing and innovation) that enable green process and product innovation. They also have brand equity and marketing competences that capture value from product innovations. Pulp SA has engineering teams that build up, from scratch, solutions to achieve superior performance in manufacturing. Ind SA established trust-based relationships with its clients and suppliers. Those have enabled the firm to develop green product innovation with a supplier and to gain competitive advantage due to anticipation of B2B clients' demands. Green product innovation at Property SA is enabled by an IT system that supports decision-making because it is a tool to monitor the field tests of new solutions. At Property SA, the guidelines for new building development (ecodesign increases market value of buildings) and due diligence processes (conducted at legal, building and environmental levels for investment or divestment purposes) create competitive advantage from green product innovation. In this case study research no evidence was found of complementary assets that enable Energy SA to increase business opportunities from their technology integration capabilities. Many of their technologies have a business opportunity in the clean energy market. However it seems that these potentialities are not being fully captured. Energy SA considers that there are trade-offs between the environment and existing competitive priorities.

5.7 Drivers, Green Capabilities, Complementary Assets and Competitive Advantage

After detailed analysis of all case studies, I found links between all elements of the framework, which contribute to the validation of the relationships drawn in the model. These comprehensive relationships were found in every case study and are detailed in Appendices 15-19.

At Property SA, the Board commitment constitutes a determinant for the implementation of a green operations strategy focused on operational efficiency and value creation. This strategy required the firm to develop capabilities for green product innovation, green process innovation, monitoring and joint problem solving. In the case of Property SA green product innovation and green process innovation are closely integrated; the other capabilities work as supporting capabilities. Property SA has defined a robust set of green project development standards that is closely integrated with an EMS (operational). To reinforce this link, Property SA implemented an IT system (external source) that monitors operations' environmental performance, facilitates decision-making processes and outputs data that support improvement measures. These measures are field-tested at prototype scale and monitored by the system; if the results are satisfactory, the idea is refined in order to be scaled, implemented and included in project development standards. The resulting green innovations increase property market value and improve operational efficiency.

At Paper SA the intensity of regulation and clients' demands drive the adoption of strategies focused on reducing pollutant emissions, natural resources use and environmental impact of products. Hence, they have capabilities to develop manufacturing processes with lower environmental impact, to increase raw materials

productivity, to do joint problem solving with researcher and experts and to develop green products. These capabilities are complemented by the use of internal multifunctional teams and by a strong brand that communicates green innovation to the market. They outperform competitors in green product lines because they create green products with high performance due to this network of capabilities.

Ind SA is a reactive firm driven by regulation and operational efficiency that acquired an external capability to identify the critical environmental issues for their business. This made them implement a green operations strategy and develop internal green capabilities to produce energy from alternative sources (biomass scraps) and reduce CO₂ emissions. The emerging green consumer trends led them to have green product initiatives, for which they developed joint problem solving capabilities with suppliers. The trust-based and long-term relationship that Ind SA has with main clients enables the firm to recognize relevant market needs and direct their green innovation efforts.

6. CONCLUSIONS

To conclude, I will summarize and discuss general findings from the case study research and present the contribution of this work project to managerial practice and to future lines of research.

Firms implement green operations strategies as a response to pressures from internal and external driving forces to deal with the environment as a constraint or an opportunity. The source of competitive advantage of these strategies is the complex internal network of resources and complementary assets. These resources may be

developed internally or acquired from external sources; nevertheless, they must be integrated with internal capabilities. As a contribution to Sharma and Vredenburg's (1998) work, competitively valuable capabilities are developed by firms regardless of the responsiveness of firms to driving forces. A firm with a mainly reactive strategy (Paper SA) developed a network of resources and complementary assets as able to create superior performance as a firm with a solely proactive strategy (Property SA).

The framework presented and the case study research bring useful insights to management practice. This paper provides managers with tools that help them reflect on the relevance of green issues to their firms and identify the most appropriate way to address them. After identifying the linkages between critical green issues and the value chain (Porter, 2006), managers that wish to develop green innovation initiatives can use the framework, the matrices and the list of green capabilities to start the definition of a green operations strategy and to acknowledge the determinants of its execution. Contributions presented in this paper can guide firms through the implementation of value-creating green initiatives.

This case study research presents several lines for future research in operations management. Firstly, it would be useful for managers to know whether green capabilities are dynamic capabilities due to the characteristics of external driving forces – environmental regulation is a dynamic field and consumers' demands for green credentials have been increasing in recent years. Secondly, firms would benefit from a deeper insight on the process of integration of external and internal capabilities – the understanding of its determinants and dynamics may even create business opportunities for providers of external capabilities. A third significant issue is whether

it is appropriate to classify firms as reactive or proactive; the case study findings show that the effect of drivers on green strategies is complex and firms oscillate between reactive and proactive behaviours. A final emergent issue is the role of IT monitoring systems and decision making structures in green operations strategies.

This work project built up a framework that structures the relationship between drivers of green operations strategies, firms' resources and green innovation as a source of competitive advantage. It provides contributions to research, but also poses questions to be explored in the future.

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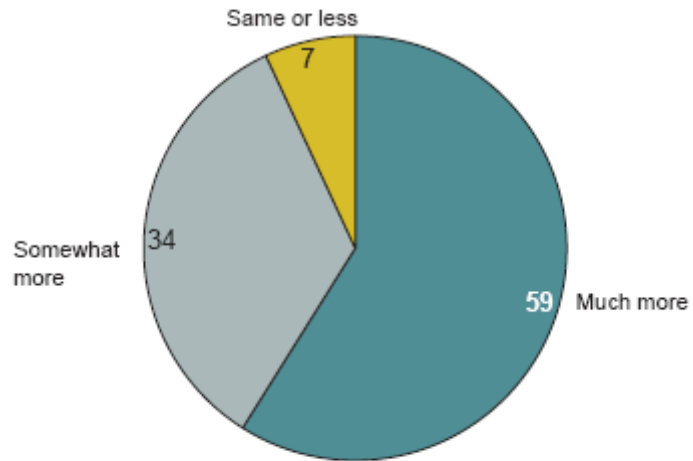
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WORK PROJECT APPENDICES

**“GREEN INNOVATION: HOW FIRMS LEVERAGE CAPABILITIES, RESOURCES AND
COMPLEMENTARY ASSETS”**

Appendix 1. Incorporation of environmental, social and governance issues in strategy

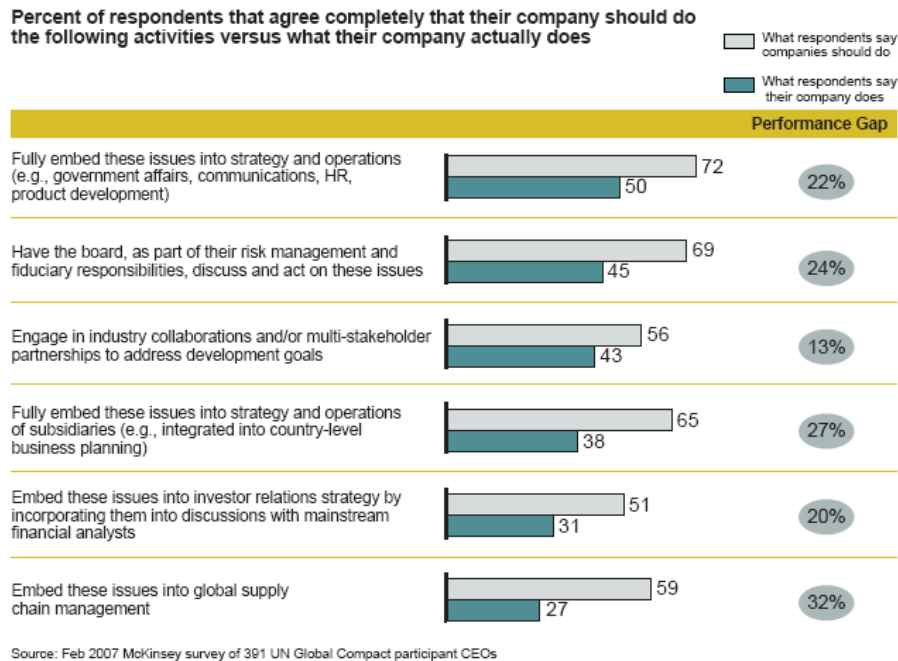
Percent of respondents that are incorporating environmental, social and governance issues into their firm's core strategy more compared to 5 years ago



Source: Feb 2007 McKinsey survey of 391 UN Global Compact participant CEOs

Source: Oppenheim, J. Bonini, S. Bielak, D. Kehm, T., Lacy, P. 2007. "Shaping the new rules of competition: UN Global Compact Participants Mirror". McKinsey&Company

Appendix 2. Performance gaps between real and intended implementation of green issues in strategy



Source: Oppenheim, J. Bonini, S. Bielak, D. Kehm, T., Lacy, P. 2007. "Shaping the new rules of competition: UN Global Compact Participants Mirror". McKinsey&Company

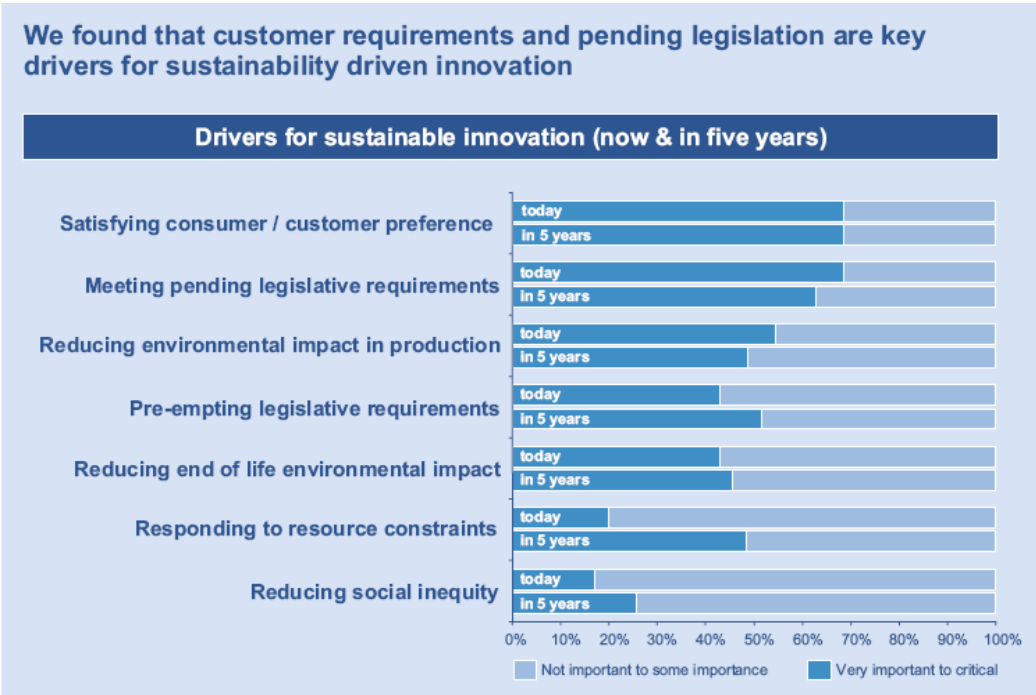
Appendix 3. Criteria used in the literature to classify green strategies

CRITERIA	LITERATURE
Extent to which the environment is a strategic priority for the firm	Azzone, 1997
Firm's strategic attitude	Azzone, 1997
Potential to explore opportunities in present or future markets	Steger, 1993
Level of environmental risk	Steger, 1993
Level of commitment of the firm's resources and management functions	Azzone, 1997; Reinhardt, 1999

Sources:

- Azzone, Giovanni. Bianchi, Raffaella. Mauri, Renato. Noci, Giuliano. 1997. "Defining operating environmental strategies: programmes and plans within Italian industries". *Environmental Management and Health*, Volume 8(1): 4-19.
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Appendix 4. Key drivers of sustainability driven innovation



Source: Keeble, Justin. Lyon, David. Vassallo, Davide. Hedstrom, Gib. Sanchez, Humberto. 2005. "Innovation High-Ground Report: How Leading Companies are Using Sustainability-Driven Innovation to Win Tomorrow's Customers". *Arthur D. Little*.

Appendix 5.Public sources of information used in preliminary screening and selection of case studies

PUBLIC SOURCES OF INFORMATION	SPECIFIC SOURCE/HISTORICAL REFERENCES
Firms' website contents	Profile, Business Areas, Sustainability and Innovation Sections, Organizational Structure, News (past 3 years)
Sustainability Reports	From 2005 to 2008
Accounts Reports	From 2005 to 2008
Other reports	Publications from the Business Council for Sustainable Development (BCSD Portugal) ²

² BCSD Portugal is a member of the regional network of the World Business Council for Sustainable Development, which is a non-profit CEO-led “platform for companies to explore sustainable development, share knowledge, experiences and best practices, and to advocate business positions on these issues in a variety of forums, working with governments, non-governmental and intergovernmental organizations”.

Appendix 6. Case study protocol – Identification of green capabilities

GREEN PROCESS INNOVATION	1	Processes to reduce resource consumption in production processes
	2	Processes to reduce pollutant emissions in production processes
	3	Processes to recover or conserve energy in production processes
	4	Processes to search for alternative sources of energy to production processes
	5	Processes to reduce the use of raw materials in production processes
	6	Generate low-cost environmental solutions for production processes
	7	Processes to introduce new production processes and green technologies
GREEN PRODUCT INNOVATION	8	Development of green products
	9	Design for lower energy consumption during use
	10	Design for elimination of harmful substances
	11	Design for substitution of virgin materials
	12	Design for dematerialization
	13	Design for lower environmental impact in production
	14	Selection of raw materials with lower environmental impacts
	15	Generation of low-cost solutions for green products
	16	Design for product recovery
	17	Design for biodegradability
	18	Design for recyclability
	19	Green packaging – lower environmental impact on production/transportation
MONITORING	20	Processes to anticipate regulatory trends
	21	Processes to screen trends in industry management practices
	22	Processes to search for the best available technologies
	23	Databases of environmental performance variables of products
	24	Memories of previous product adaptations and associated performance
	25	Analysis of product life-cycle
	26	Processes to share and diffuse internally relevant environmental information
	27	Identification of environmental impact of firms' operations
	28	Processes to disclose corporate environmental performance within the firm
JOINT PROBLEM SOLVING	29	Collaborative inter-department processes of joint problem solving
	30	Multifunctional teams (within the firm)
	31	Multifunctional teams (inter-organizations)
	32	Periodic meetings with top and middle management to address relevant environmental issues
SUPPLY CHAIN BONDING	33	Sales of scraps or by-products disposed of in production processes
	34	Selection of transportation modes / carriers according to environmental criteria
	35	Management activities to support product recovery / take-back schemes
	36	Coordination of supply chain partners for reverse logistics
	37	Processes to define and update environmental suppliers' criteria
	38	Integration of environmental criteria of procurement and suppliers' selection
RELATIONSHIP WITH STAKEHOLDERS	39	Processes to incorporate stakeholders contributions in innovation initiatives
	40	Work with stakeholders in joint problem solving to address environmental issues
	41	Disclosure and report of relevant corporate environmental information
	42	Initiatives to establish relationships with stakeholders (consortia; conferences)
	43	Communication with stakeholders related to corporate impacts and initiatives
	44	Lobby and advocacy for relevant environmental issues
	45	Negotiation (license to operate, "not in my backyard" effect, controversies)
HUMAN RESOURCE ENGAGEMENT	46	Training programs to natural resource and biodiversity conservation
	47	Training for specific environmental issues regarding operational routines
	48	Incentive schemes to reward voluntary pro-environment behaviour at work
	49	Operational budget flexibility to experiment different environmental solutions

(based on Day, 1994; Wong et al, 1996; Azzone et al, 1997; Sharma & Vredenburg, 1998; Corbett & Klassen, 2006)

Appendix 7. Criteria to assess proactivity of green strategy

1. DRIVING FORCES OF ENVIRONMENTAL INITIATIVES	SCORES
Voluntary: internal driver	5
Voluntary: holding/parent firm	4
Driver: consumers and NGO	3
Driver: industry or sector standards	2
Driver: clients	1
Driver: regulation	1
2. INTENSITY OF ENVIRONMENTAL REGULATION	SCORES
Environmental licensing	1
Industry regulator body	2
Applicable environmental legislation	3
3. CONNECTION OF ENVIRONMENTAL INITIATIVES WITH CORPORATE GOALS	SCORES
Strategic (long-term, corporate)	3
Tactical (short-term, local)	2
Not linked with corporate objectives	1
4. FREQUENCY OF ENVIRONMENTAL INITIATIVES	SCORES
Consistent, scheduled and frequent pattern	2
Single ad-hoc problem solving	1
5. EXTENSION OF ENVIRONMENTAL INITIATIVES	SCORES
Corporate	2
Single department	1
6. DECISION STRUCTURE FOR ENVIRONMENTAL INITIATIVES	SCORES
Participation of department management in process changes decisions	1
Participation of department management in product changes decisions	1
Participation of department management in environmental responses decisions	2
Participation of department management in corporate environmental policies decisions	3

NOTE: In each category, the highest score was given to the highest level of proactivity and the lowest score to the lowest level of proactivity.

Appendix 8. Data to assess outcomes of innovation and sustainability expenditure

1. DEGREE OF INNOVATION	Investment in R&D (%; EUR)
	Sales of innovative products in the last 3 years (%; EUR)
	Number of new products /lines in the last 3 years
2. DIMENSION	Sales volume
3. INVESTMENT IN GREEN INNOVATION	In % of the investment in innovation or in EUR
	Time spent in green product/process development
	People/departments allocated to these initiatives
4. IMPACT OF GREEN PRODUCT AND GREEN PROCESS INITIATIVES	Cost reductions
	Sales increase
	Reputation
	Product quality increase
5. ENVIRONMENTAL INITIATIVES	Environmental performance
	Finished
	On-going

Appendix 9. Responsiveness score for each case study

VARIABLES OF RESPONSIVENESS	Paper SA	Pulp SA	Property SA	Ind SA	Energy SA
DRIVING FORCES OF ENVIRONMENTAL INITIATIVES	2.3	2.6	5.0	2.3	1.5
INTENSITY OF ENVIRONMENTAL REGULATION	1.0	1.0	3.0	2.0	3.0
CONNECTION OF ENVIRONMENTAL INITIATIVES WITH CORPORATE OBJECTIVES	3.0	3.0	3.0	2.5	3.0
FREQUENCY OF ENVIRONMENTAL INITIATIVES	2.0	2.0	2.0	2.0	2.0
EXTENSION OF ENVIRONMENTAL INITIATIVES	2.0	2.0	2.0	2.0	2.0
DECISION STRUCTURE FOR ENVIRONMENTAL INITIATIVES	1.0	3.0	1.0	0.0	3.0
TOTAL SCORE	11.3	13.6	16.0	10.8	14.5

Appendix 10. Identification of green capabilities and assets (identification of resources and processes) in Energy SA

<p>GREEN PRODUCT INNOVATION</p> <ol style="list-style-type: none"> 1. Application of engineering knowledge and know-how to the energy and environment sector 2. Product recovery and repairing 3. Some ecodesign small scale projects 	<p>JOINT PROBLEM SOLVING</p> <ol style="list-style-type: none"> 1. <i>Fora</i> for information and knowledge sharing but no mature processes 2. Partnerships with Universities 	<p>RELATIONSHIPS WITH STAKEHOLDERS</p> <ol style="list-style-type: none"> 1. Management system to collect and reward employees' ideas
<p>GREEN PROCESS INNOVATION</p> <ol style="list-style-type: none"> 1. Some business units certified by ISO14001 (but no corporate EMS) 2. Efforts to reduce materials (high burden in costs) 	<p>MONITORING</p> <ol style="list-style-type: none"> 1. Diffusion: Intranet Portal and internal magazine 2. Diffusion: Sustainability Report 	<p>HUMAN RESOURCE ENGAGEMENT</p> <ol style="list-style-type: none"> 1. Bonus scheme for production staff: small percentage for environment and safety criteria 2. Intranet portal dedicated to Sustainable Development
	<p>SUPPLY CHAIN BONDING</p> <p>No reported processes</p>	

Appendix 11. Identification of green capabilities and assets (identification of resources and processes) in Ind SA

<p>GREEN PRODUCT INNOVATION</p> <ol style="list-style-type: none"> 1. High value products made from lower value materials (scraps, recycled materials) 2. Innovative product developed with a chemicals' supplier in a partnership – lower environmental impact 	<p>JOINT PROBLEM SOLVING</p> <ol style="list-style-type: none"> 1. Board committee dedicated to sustainability related issues 2. External sustainable development networks: WBCSD and industry associations 3. R&D Center – new materials and processes 4. Partnerships and collaborations with suppliers and universities 5. Beginning the creation of multifunctional and multinational working groups → intend to be an internal capability 	<p>RELATIONSHIPS WITH STAKEHOLDERS</p> <ol style="list-style-type: none"> 1. Member of WBCSD and other industry and environment-focused associations 2. Consistently include contributions from clients 3. Sustainability forum organized by the Holding firm
<p>GREEN PROCESS INNOVATION</p> <ol style="list-style-type: none"> 1. Eco-efficiency is strategic goal 2. Sustainable sourcing of materials 3. Main raw materials used are low-value materials originated from industrial residues and post-consumer wood waste 4. Process heat needs are supplied locally using integrated thermal energy facilities 5. Water recycling in industrial facilities when relevant 	<p>MONITORING</p> <ol style="list-style-type: none"> 1. Integration of sustainability aspects into management systems and continuous improvement 2. Risk management and legislation compliance 3. Corporate environmental surveys in all production units with analysis and feedback systems 	<p>HUMAN RESOURCE ENGAGEMENT</p> <ol style="list-style-type: none"> 1. Training
	<p>SUPPLY CHAIN BONDING</p> <ol style="list-style-type: none"> 1. Sustainable natural resource management and certification initiatives 2. Close, long-term relationships with suppliers – planning of supplies and assurance of quality level 3. Iberian centres to collect and process post-consumer waste to integrate in manufacturing 	

Appendix 12. Identification of green capabilities and assets (identification of resources and processes) in Paper SA

<p>GREEN PRODUCT INNOVATION</p> <ol style="list-style-type: none"> 1. A dedicated line of branded green products (using less material for the same quality) and a green product in some other branded product lines (recycled content) 2. Products have natural resource management certification 3. R&D activities to obtain scientific and technologic know-how to integrate in business and product development (extension of brand lines; new products, new markets) 	<p>JOINT PROBLEM SOLVING</p> <ol style="list-style-type: none"> 1. Marketing and production working together 2. Natural resource management R&D center – Consortium - The firm, Universities and industry associations → Findings feed back into the manufacturing process 3. Own a company dedicated to natural resource management 4. Preparatory compliance to new regulation on chemicals → identification and listing of relevant substances in cooperation with sector firms 5. High-tech innovation: consortium with state of the art technology firms 	<p>RELATIONSHIPS WITH STAKEHOLDERS</p> <ol style="list-style-type: none"> 1. Not a strength in the industry; mainly with shareholders and clients 2. Member of National and European industry associations, environment-focused business associations and certification organizations 3. Close relationship with suppliers 4. Biodiversity conservation initiatives 5. Actively working on a draft for a national certification scheme and standards for natural resource management 6. Involvement of stakeholders on biodiversity management (Business for biodiversity voluntary initiative)
<p>GREEN PROCESS INNOVATION</p> <ol style="list-style-type: none"> 1. Continuous improvement of processes through EMS 2. Reductions in materials, water and energy use at specific levels 3. Sustainable forestry management - FSC and PEFC certifications for the forest and the chain of custody 4. Waste recovery 5. Energy producer – Cogeneration – Auto-sufficiency 6. Three patented industrial processes 7. R&D projects inside the firm 	<p>MONITORING</p> <ol style="list-style-type: none"> 1. Screening of future legislation through industry associations 2. Anticipation of future obligations – REACH 3. Assessment of natural resources under the firm's management 4. Guidelines for implementation of Biodiversity Plans 5. Risk management (natural resource protection) 	<p>HUMAN RESOURCE ENGAGEMENT</p> <ol style="list-style-type: none"> 1. Employee annual training plan
	<p>SUPPLY CHAIN BONDING</p> <ol style="list-style-type: none"> 1. Supply chain certification 2. Initiative for sharing among the sector companies good biodiversity practices throughout the industry's supply chain 	

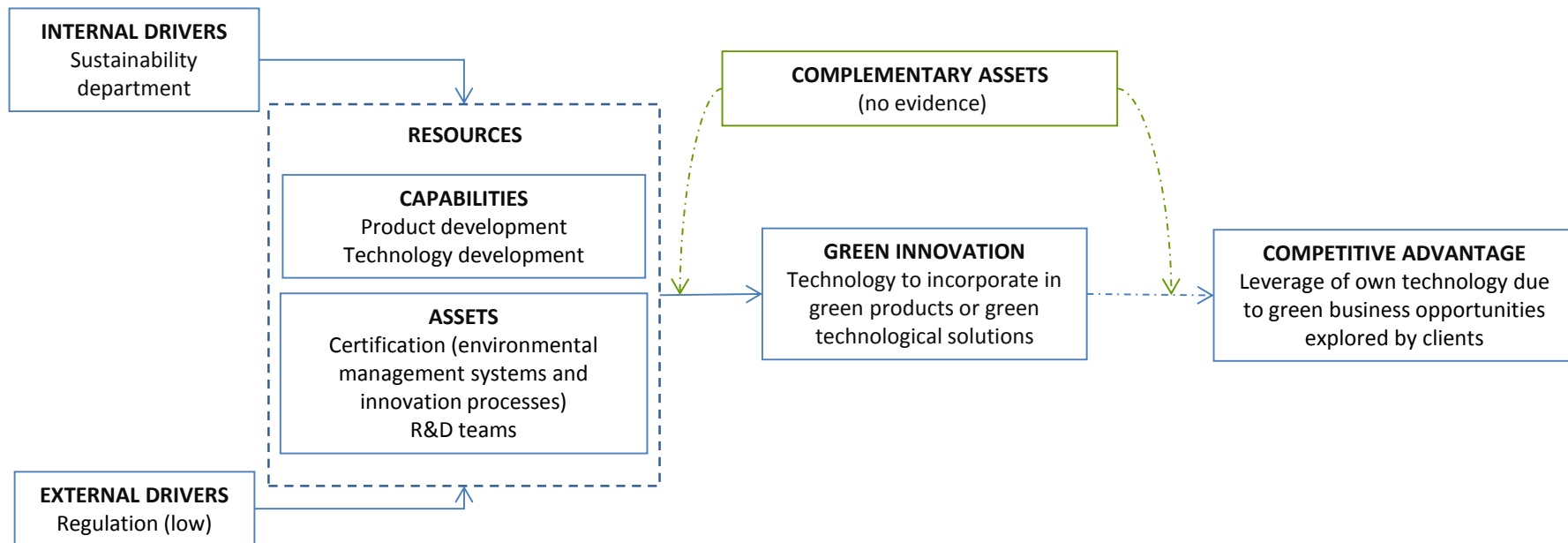
Appendix 13. Identification of green capabilities and assets (identification of resources and processes) in Pulp SA

GREEN PRODUCT INNOVATION 1. Commodity: No product innovation 2. Product follows an European ecolabelling set of criteria	JOINT PROBLEM SOLVING 1. Group that integrates the operation and revision of all management systems 2. Industrial department and management systems work together 3. All management systems integrated in one department	RELATIONSHIPS WITH STAKEHOLDERS 1. Member of environment-focused organizations and associations to promote innovation 2. Voluntary biodiversity and conservation programmes
GREEN PROCESS INNOVATION 1. Natural resource management and certification 2. Internal energy sources – self-sufficiency – energy generated from scraps and by-products 3. Continuous improvement of processes – internal engineering capabilities	MONITORING 1. Total Quality Management 2. Performance communication: daily and weekly internal meetings, sustainability report, internal magazine, intranet 3. Screening of future legislation through industry associations 4. Anticipation of future obligations – REACH 5. Improvement programmes – databases with corrective and preventive measures	HUMAN RESOURCE ENGAGEMENT 1. Certification requirements: Participation of staff in improvement programs 2. Intranet system for employees participation with incentives – Not frequently used because there's a culture of daily participation within the company 3. Internal training
	SUPPLY CHAIN BONDING 1. Qualification and assessment of suppliers 2. Training to service providers 3. System of qualification of service providers	

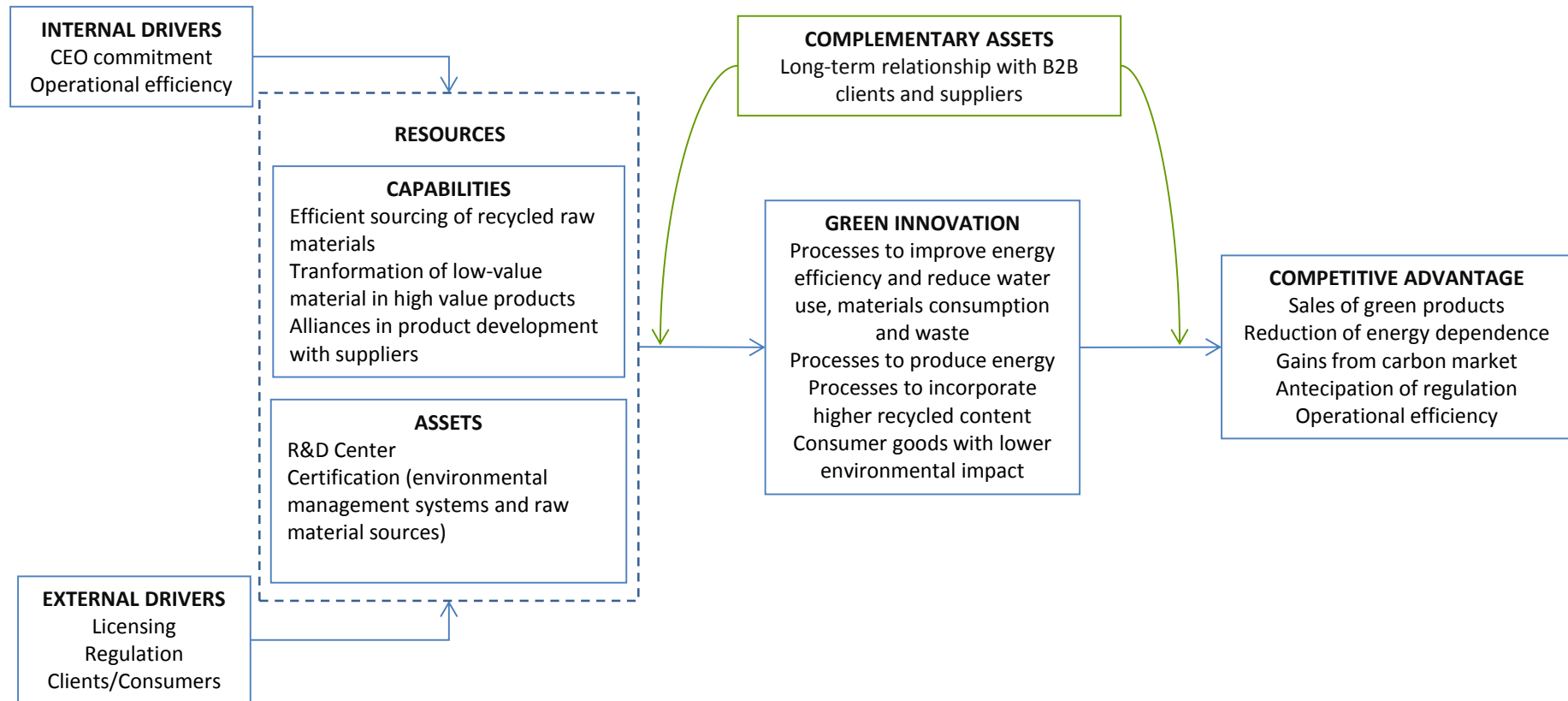
Appendix 14. Green capabilities and assets (identification of resources and processes) in Property SA

<p>GREEN PRODUCT INNOVATION</p> <ol style="list-style-type: none"> 1. Environmental criteria in project development standards that are revised periodically (based on pilot project testing, Best Available Technologies and certification systems like LEED/BREEAM) 2. Procedures to evaluate environmental variables for new business development (site assessment, due diligence) 3. Green building concept supported by EMS and development standards 	<p>JOINT PROBLEM SOLVING</p> <ol style="list-style-type: none"> 1. Collaborative work between Environment and Marketing 2. Corporate-wide environment working group: people from several areas and functions 3. Active participation in working groups of industry associations and of the World Business Council for Sustainable Development (WBCSD) to address relevant environmental issues 	<p>RELATIONSHIPS WITH STAKEHOLDERS</p> <ol style="list-style-type: none"> 1. Independent person that responds to stakeholder concerns and CR Reports feedback tools 3. EMS training for clients and suppliers 3. Lobby to influence regulation definition and industry standards 4. Representation in WBCSD and industry-specific environment working groups 6. Focus groups with stakeholders during product development phase
<p>GREEN PROCESS INNOVATION</p> <ol style="list-style-type: none"> 1. Environmental management systems support innovations at process levels, combined with project development standards 	<p>MONITORING</p> <ol style="list-style-type: none"> 1. Environmental intranet: main access to relevant EMS information; internet-based tool to manage/analyze data 2. Annual internal/external audits and review of relevant impacts 3. Management review 4. Main monitoring requirements: legal requirements, improvement action plans, regular environmental reports, compliance with project development standards, training 6. References by the media 7. Diffusion: Public portal, reports disclosure, Board report, Internal follow-up reports 	<p>HUMAN RESOURCE ENGAGEMENT</p> <ol style="list-style-type: none"> 1. Programmes to collect new ideas from employees 2. Internal mailing to raise environmental awareness 3. Environmental training programmes 4. Bonus schemes include voluntary compliance to CR criteria
	<p>SUPPLY CHAIN BONDING</p> <ol style="list-style-type: none"> 1. Responsible procurement policy 2. CR criteria for service providers 3. Questionnaires to suppliers (Scoring tool) 4. Environmental training for clients 	

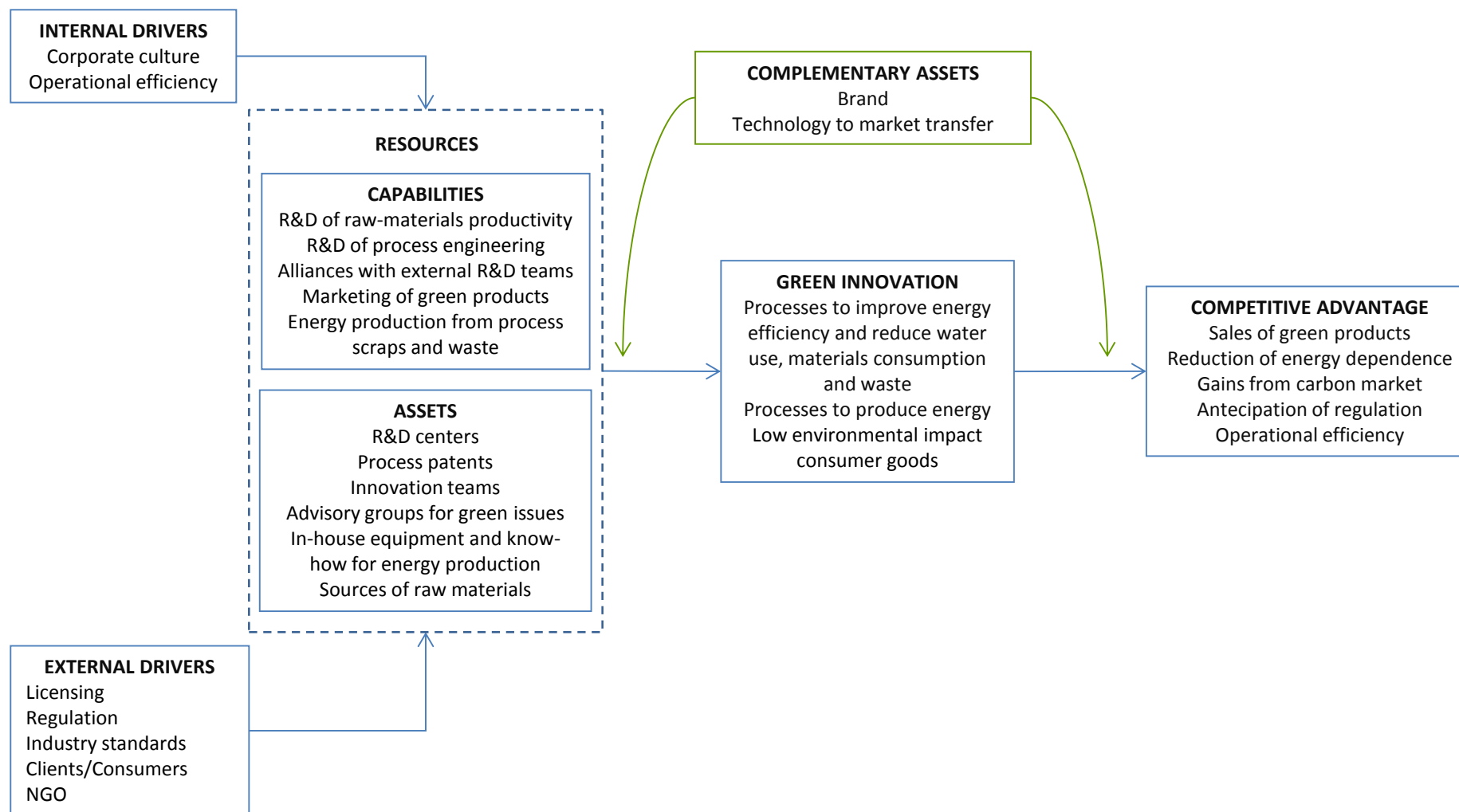
Appendix 15. Green capabilities and assets of Energy SA and their fit in the framework



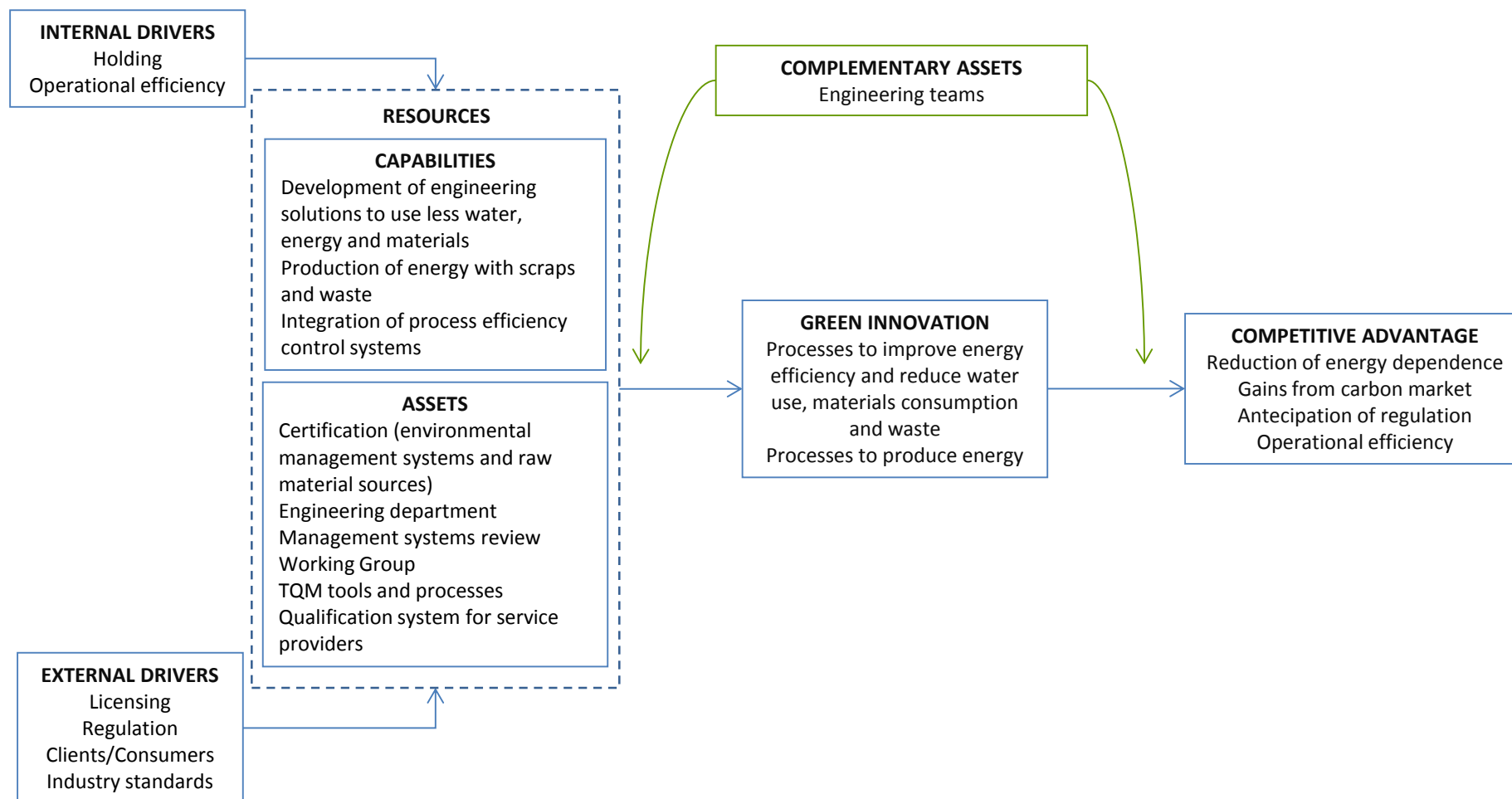
Appendix 16. Green capabilities and assets of Ind SA and their fit in the framework



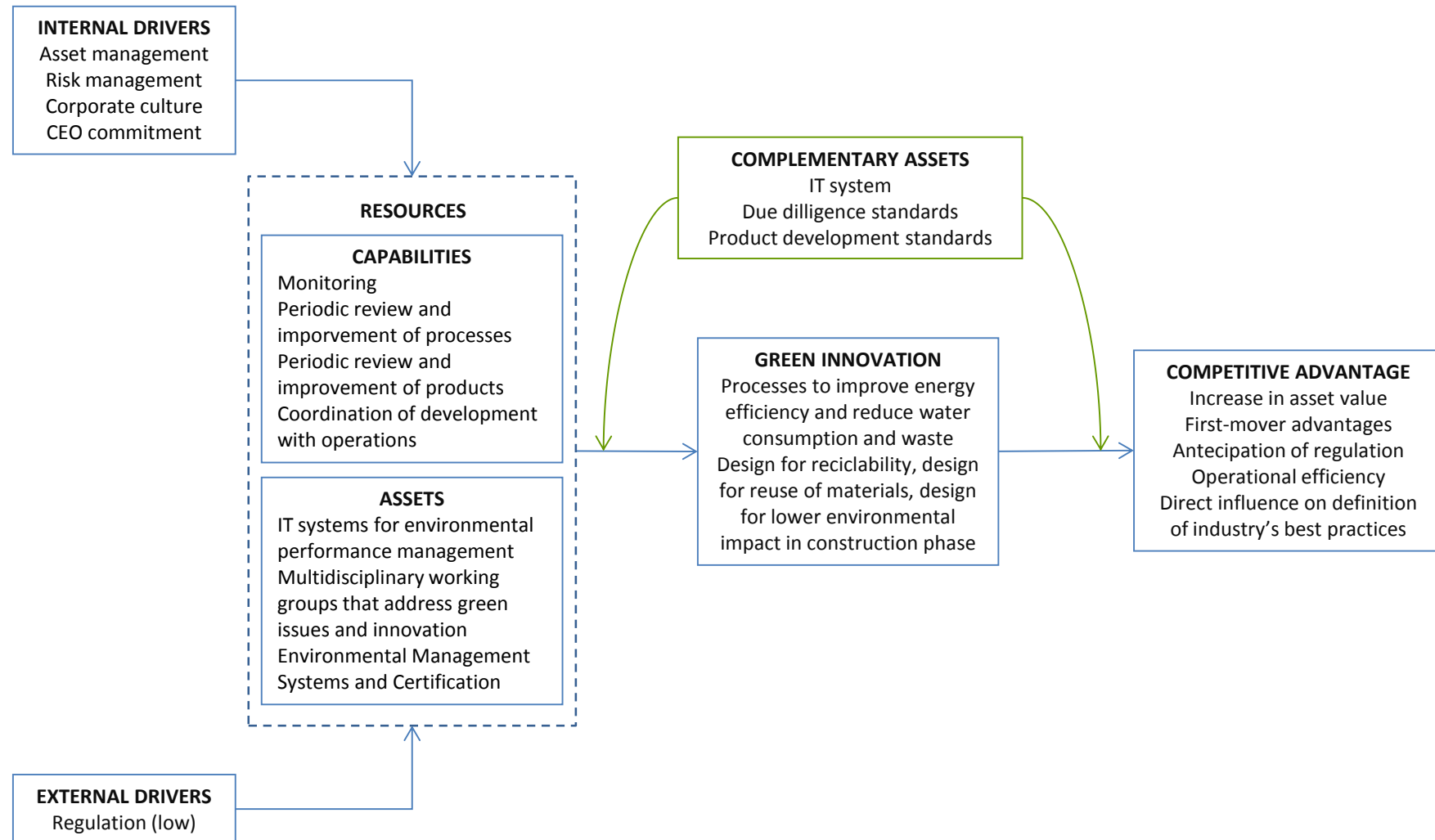
Appendix 17. Green capabilities and assets of Paper SA and their fit in the framework



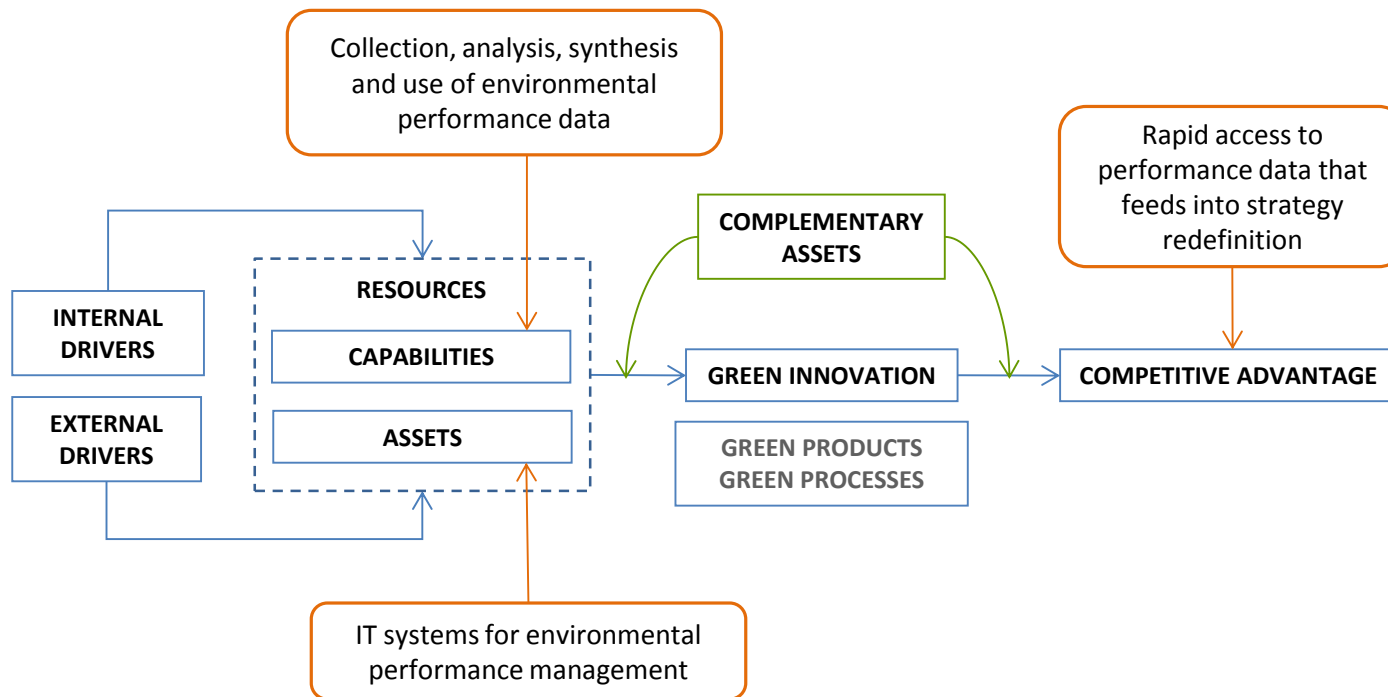
Appendix 18. Green capabilities and assets of Pulp SA and their fit in the framework



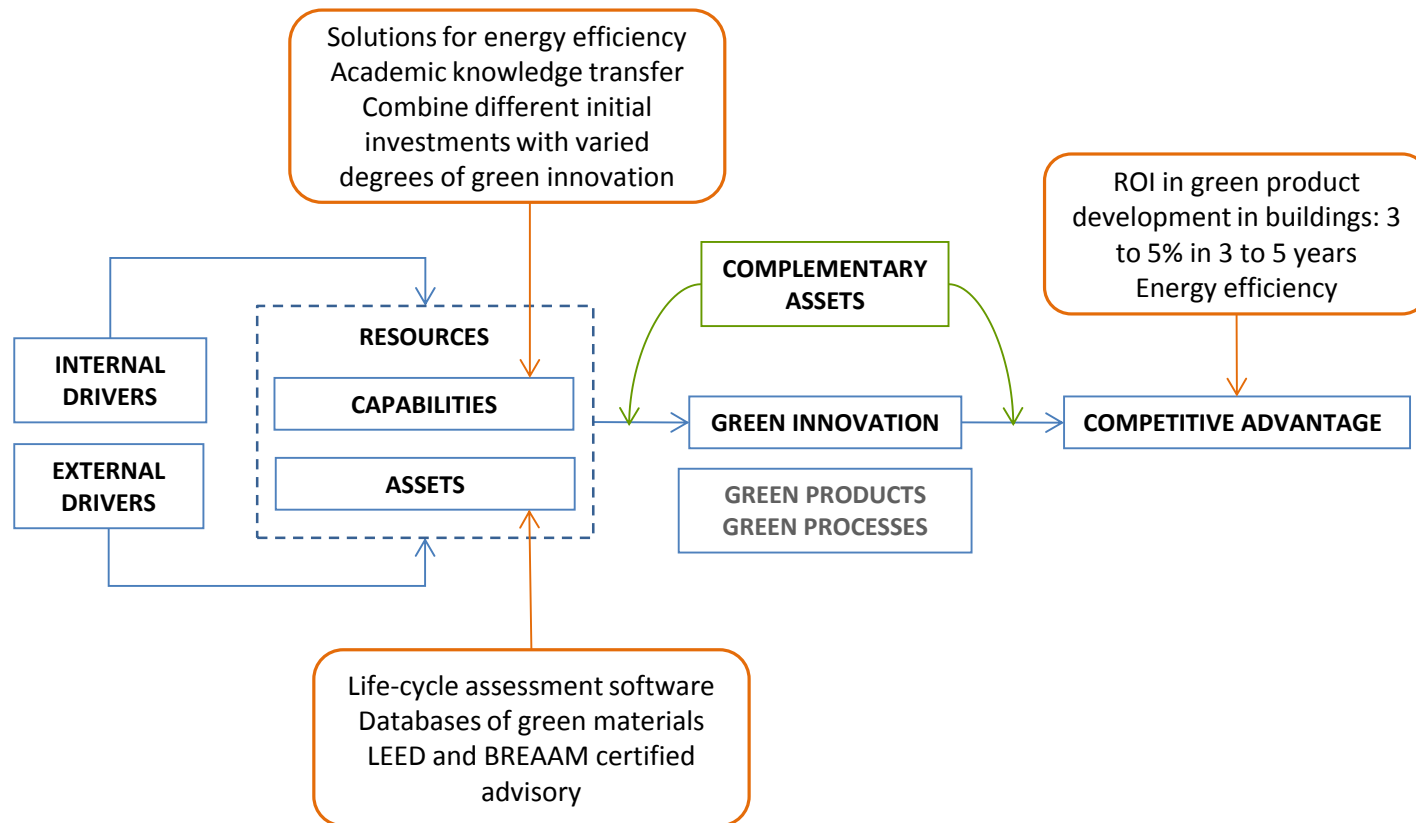
Appendix 19. Green capabilities and assets of Property SA and their fit in the framework



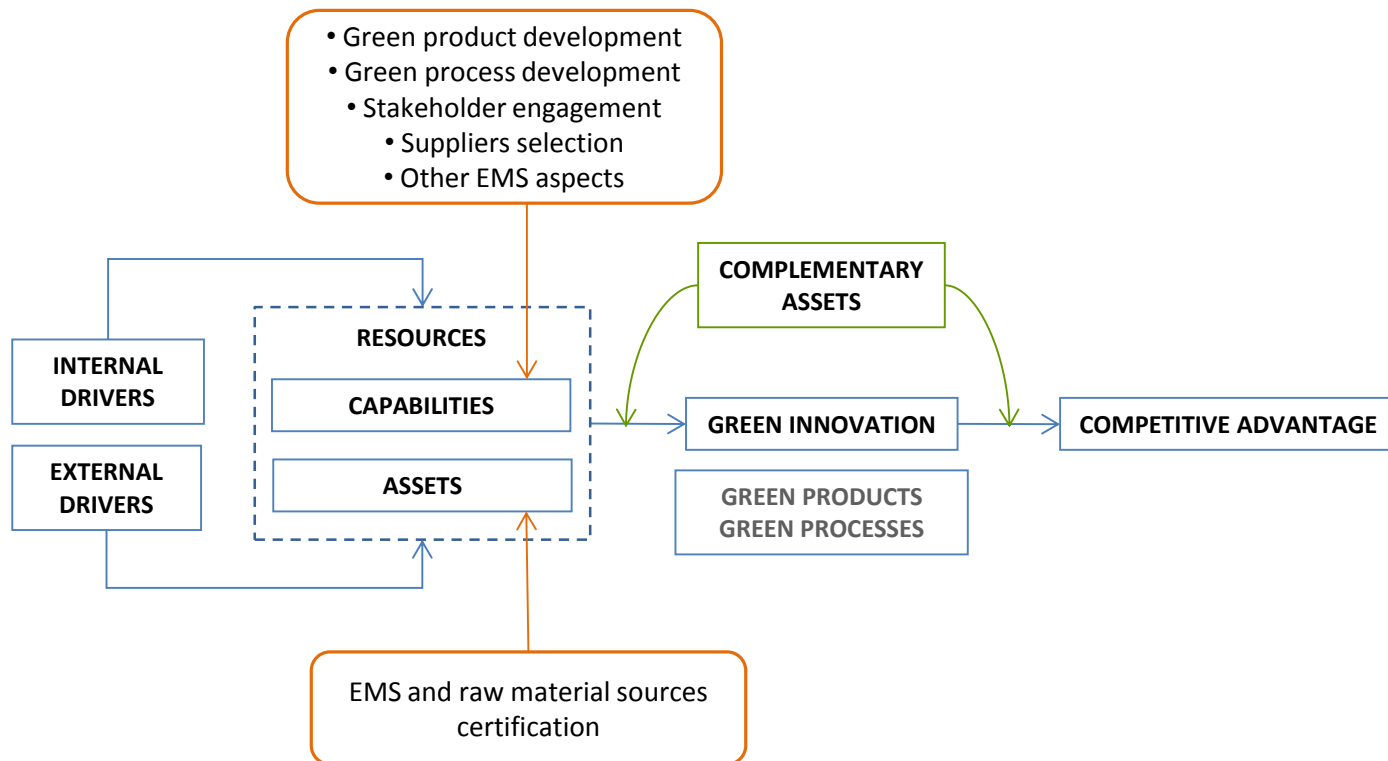
Appendix 20. Identification of external monitoring capabilities available in the market – Information Technology (Source: IT SA)



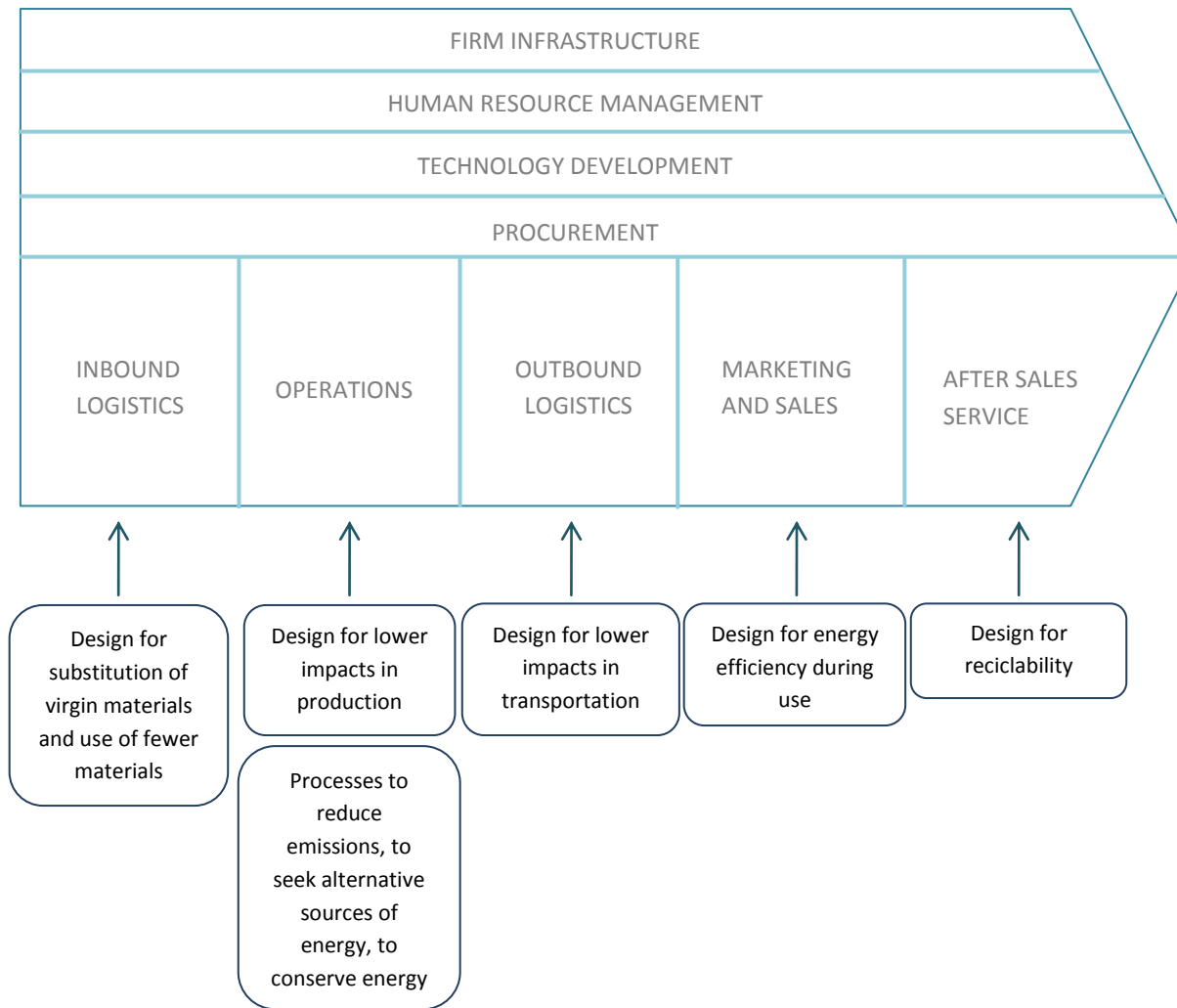
Appendix 21. Identification of external green capabilities available in the market – Construction (Source: Bio SA)



Appendix 22. Identification of external green capabilities available in the market – Environmental Management (Source: Eco SA)



Appendix 23. Generic green product and process innovation capabilities along the value chain



Appendix 24. Links between green capabilities found in case studies

GREEN CAPABILITIES	Green Process Innovation	Green Product Innovation	Monitoring	Joint Problem Solving	Supply Chain Bonding	Relationship w/ stakeholders	H.R. Engagement
Green process innovation		Paper SA,Property SA	Paper SA,Property SA	Paper SA,Property SA, Pulp SA	Ind SA,Paper SA,Pulp SA		
Green product innovation	Paper SA,Property SA		Energy SA,Ind SA,Paper SA,Property SA	Ind SA,Energy SA,Paper SA,Property SA			Property SA
Monitoring	Paper SA,Property SA	Energy SA,Ind SA,Paper SA,Property SA		Ind SA,Property SA	Ind SA,Pulp SA	Ind SA,Paper SA, Pulp SA	
Joint problem solving	Paper SA,Property SA, Pulp SA	Ind SA,Energy SA,Paper SA,Property SA	Ind SA,Property SA			Paper SA,Ind SA, Pulp SA, Property SA	
Supply chain bonding	Ind SA,Paper SA,Pulp SA		Ind SA,Pulp SA				
Relationship w/ stakeholders			Ind SA,Paper SA, Pulp SA	Paper SA,Ind SA, Pulp SA, Property SA			
H.R. engagement		Property SA					